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INTENTIONAL CHEMICAL DISASTERS

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An *intentional chemical disaster* (ICD) is defined as the intentional release or spill of a toxic chemical that results in an abrupt and serious disruption of the functioning of a society, causing widespread human, material, or environmental losses that exceed the ability of affected society to cope when using only its own resources. This definition would include the consequences resulting from chemical warfare, chemical terrorism, and industrial sabotage.

CHEMICAL DISASTERS: UNINTENTIONAL VERSUS INTENTIONAL

Incidents involving either the slow or explosive release of chemicals are common. From 1988 to 1992, more than 34,000 chemical release events were reported in the United States (1). Most of these incidents did not cause mass casualties. However, some rare events do have the potential to cause serious harm on a mass scale. The Bhopal disaster killed over 2,500 persons and affected an additional 200,000 (2). In 1984, a fuel truck crash in the Salang Tunnel in Afghanistan killed 2,700 people. In 1947, a shipload of ammonium nitrate fertilizer exploded in Texas City, Texas, killing 576 persons (3).

Both ICDs and unintentional industrial disasters tend to receive significant international media attention and publicity. The public tends to judge all technologic hazards more harshly than natural hazards of a similar magnitude, and it views them with a heightened concern and perception of risk (3,4). In the public eye, these categories of technologic catastrophes no longer represent localized emergencies, but they are "trends that unravel the very fabric of existing organized systems" (5). These events change the very nature of response actions as responders are no longer performing a well-rehearsed technical or logistical procedure. Assessments become less certain and older forms of intelligence gathering become obsolete. Decision making becomes less centralized and more interdependent, and it may be influenced by both local and distant theaters of operation. Responders are forced to act in a collective and integrated fashion within a nonconventional network, the leaders of which are also unfamiliar with catastrophic breakdown phenomena of this nature. Any event involving an ICD is likely to involve both traditional and nontraditional responders, as the scope of the incident extends beyond traditional roles and responsibilities. Such events would possibly involve the participation of responders acting on both local and national levels (Table 33.1).

ICDs involving the use of commercial or industrial chemical agents have the potential to cause a major public health disaster that is higly comparable to that of known military agents. In some cases, industrial agents may even be more likely to be used as a weapon of choice by terrorists. Their ease of availability, toxicity, and low cost may

TABLE 33.1. EXAMPLES OF TRADITIONAL AND NONTRADITIONAL EMERGENCY RESPONDERS

Traditional emergency response	Nontraditional emergency response
Bystanders	Medical and environmental laboratories
EMS and the 911 activation system	Public health departments
Police	Metropolitan Medical Response system
Fire and rescue	Outpatient clinics and hospitals
Public and private hazardous material response teams	Mass transit and port authorities
Emergency departments	Military and National Guard, Coast Guard
Regional poison control centers	Federal agencies, including FBI, FEMA, EPA, PHS, CDC, and DOE

Abbreviations: CDC, Centers for Disease Control and Prevention; DOE, Department of Energy; EMS, emergency medical services; EPA, Environmental Protection Agency; FBI, Federal Bureau of Investigation; FEMA, Federal Emergency Management Agency; PHS, Public Health Service.

make these toxic chemicals attractive to the potential terrorist. Thus, even though the focus may, at times, appear to be placed inordinately on the consequence management of terrorism involving military agents, such as that for vesicants or nerve agents, chemical terrorism actually may have a greater potential to occur in the form of a toxic chemical spill or release involving industrial or commercial products (6). In that sense, the prevention and control measures for intentional chemical disasters align quite closely with those for catastrophic industrial disasters. *In effect, the main difference between industrial disasters and those of chemical sabotage, warfare, and terrorism may be a distinction only of malicious intent.* Thus, efforts to enhance hazardous material (HazMat) preparedness and response activities for the most common chemical emergencies will also serve to better the preparations for terrorist events. Conversely, consequence management focused on chemical terrorism should have the added value of building capacity for responding to the common HazMat emergencies and rare catastrophic chemical disasters.

DISASTER MEDICINE AND INTENTIONAL CHEMICAL DISASTERS

Disaster medicine is "the science that seeks to address the adverse health and medical effects associated with disasters . . . and [it] includes prevention, emergency response, and recovery needs of affected individuals and populations" (7). The science of disaster medicine is founded in multidisciplinary medical skills that bridge the curative and preventive spectrum of health care (8). In this sense, disaster medicine serves to combine the disciplines of clinical and public health promotion effectively, and it is not limited to the provision of emergency care.

One defining characteristic of disaster medicine is the involvement of the management of an extremely wide range of emergency health issues (Table 33.2). Consequence detection and management after an ICD event will probably also involve almost all of these same interrelated issues.

INTENTIONAL CHEMICAL DISASTERS: HISTORICAL PERSPECTIVE

Numerous examples of ICDs can be found throughout history. Toxic chemicals were reportedly used by the ancient Chinese and the Greeks. Chemical weapons were also used during the Boer War, the Russo-Japanese War, and World War I. Of the 26 million casualties suffered in World War I, nearly 1 million were chemical-related (9). Of the total 272,000 United States casualties, 72,000 (26%) were chemical casualties (9). During World War II, Japan and Italy both used chemical warfare agents. The United States Army is known to have used defoliants and nonlethal riot control agents during the Vietnam War. In 1963, Egypt used riot control, mustard, and nerve agents against royalists during the Yemen civil war. The Soviet Union used mustard gas and nerve agents during the Afghanistan War throughout the 1980s. During the Iran-Iraq War, the United Nations was able to verify that Iran used mustard gas, lewisite, and nerve agents against the Iranian troops. Roughly 5% of the Iranian casualties were caused by chemical agents (10). Reports exist of Iraq using chemical agents against its Kurd minority. Libya is reported to have used chemical weapons that it obtained from Iran during an invasion of Chad. Reports have also been made of Cuban-backed Angolan forces using nerve agents against rebel forces (9).

Ironically, during the Persian Gulf War, persons were adversely affected as a result of personal protection measures, not as a result of chemical attack (11–13). However, the Iraqis were responsible for causing a large ICD in 1991 as a result of setting a multitude of oil wells on fire in Kuwait (14). In 1994, an act of terrorism had the potential to become an ICD when the Japanese religious cult Aum Shinrikyo released sarin nerve agent in a residential area of Matsumoto, Japan. This event killed seven and injured 500. The same terrorist group struck again during 1995 in the now infamous Tokyo subway sarin attack, which killed 12 and affected over 5,000 (15). However, the incident did not result in a serious disruption in the functioning of Japanese

TABLE 33.2. EMERGENCY HEALTH ISSUES RELATED TO DISASTER MANAGEMENT

Injury prevention and control	Prehospital care and Emergency Medical Services
Health information systems	Emergency medicine
Epidemiology	Toxicology
Occupational health	Hazardous material emergency response
Mass shelter and displaced populations	Mass casualty management and triage
Civilian-military coordination	Field-based logistics and communications
Environmental health	Incident command systems
Population protection measures	Traumatology and resuscitation
Disease control	Mental health

society. Nor did it cause widespread human, material, or environmental losses that exceeded the ability of affected society to cope using only its own resources. Therefore, in this sense, the Tokyo subway event would not be considered an ICD.

Fortunately, the potential ICD events after World War I have not generated the number of mass fatalities consistent with chemical disasters associated with industrial releases, such as the thousands killed at Bhopal. However, this does not mean that such an attack does not have the potential to harm hundreds, if not thousands, of victims. Were miscalculation and lack of experience not part of chemical terrorist attacks in the past, many more casualties and deaths would likely have occurred. For example, in the 1995 Tokyo subway attack, an impure preparation of sarin was used as part of a crude binary weapon and was not effectively aerosolized. The perpetrators also underestimated the air exchange capabilities of the subway system. As a result, a multisource attack on a commuter target cohort of 80,000 persons resulted in only 12 deaths. While 5,510 sought treatment, only 17 were actually considered critical (i.e., requiring ventilatory support), 37 patients were diagnosed as severe (i.e., exhibiting nausea, vomiting, or dyspnea), and 984 had complaints limited to eye involvement, symptoms that were consistent with miosis) (15).

During the 1996 Olympic games in Atlanta, considerable efforts were made to prepare for terrorist attacks that could have included chemical weapons. Within hours of an explosion of a pipe bomb in Atlanta's Olympic Centennial Park, samples were collected from near the bomb crater and were sent to an analytical laboratory at the Centers for Disease Control and Prevention to be screened for the presence of chemical and biologic warfare agents. The laboratory and the associated response system, called the Science and Technology Center (16), were based at the National Center for Environmental Health and were specifically created to form a broad multiagency partnership among federal assets. This Federal Bureau of Investigation (FBI)-led federal effort sought to enhance the capability of the United States to respond rapidly to chemical or biologic terrorism. The Atlanta experience marked one of the first times when a domestic bomb was rapidly screened for these agents of mass destruction. This partnership effectively and urgently filled a void in the national analytical and response capacities, and it became a prototype for the future development of national-level crisis and consequence management involving terrorism (17).

DETECTION AND MANAGEMENT OF THE CONSEQUENCES OF INTENTIONAL CHEMICAL DISASTERS

Detection and management are two critical functions served by emergency responders after an ICD event. Responders will have urgent and complex informational needs regarding *consequence management*, a term defined by the Presidential Decision Directive 39 released June 21, 1995. Conversely, responders on the scene will provide a valuable resource to offsite governmental and national security decision-makers for information and intelligence regarding *consequence detection* (18).

Consequences of particular relevance to disaster medicine include the environmental release or exposure *incident* and any resultant casualties or patient *cases* (18) (Table 33.3).

Consequence Detection

Early detection of the consequences of intentional chemical disasters may be expected to result from the local discovery of the environmental release or exposure *incident* event or the diagnosis of the resultant patient *cases*. Among other activities detailed in Table 33.4, responders may provide critical on-scene assessments and patient examinations that distant consultants are unable to perform in a timely manner. They may supply an informal passive surveillance system and serve as nationwide monitors in reporting potential events in a fashion that is timely enough to allow for rapid intervention (Table 33.4). Consequence detection after an event may also be facilitated by advance warning from preincident intelligence that serves to alert responders to watch for subsequent cases or incidents.

Consequence Management

To manage effectively the complex and rare incidents and casualties that may occur as a consequence of an ICD, responders require expert consultation and informational

TABLE 33.3. ELEMENTS OF CONSEQUENCE DETECTION AND MANAGEMENT FOR INTENTIONAL CHEMICAL DISASTERS

Consequences	Detection	Management
Cases (or casualties)	Case detection	Case management
Incidents (or release)	Incident detection	Incident management

TABLE 33.4. DISASTER MEDICINE ACTIVITIES RELATED TO CONSEQUENCE DETECTION

Activity	Case detection	Incident detection
Intelligence	Preincident intelligence Medical education	Preincident intelligence Hazard awareness and recognition
Testing	Point-of-care assays Clinical laboratory tests	Hazard identification Boundary demarcation Exposure assessment Laboratory reporting
Monitoring	Health information systems Passive and active surveillance Case definition	Environmental monitoring Hazardous substance emergency event surveillance system
Diagnosis	Clinical examination Laboratory evaluation	Epidemiologic assessment Scene assessment

support. These informational needs regarding case management will likely include diagnostic and treatment modalities. Questions involving incident management will generally be focused on assessment and control of the complex chemical release scene itself. Incident management response actions are expected to be, to a large extent, scenario-dependent according to the particular agent and the degree of warning. Informational needs regarding case management might include, but would not remain limited to, issues of case control and casualty care (Table 33.5).

PREVENTION AND CONTROL MEASURES

Risk Management for Intentional Chemical Disasters

Risk assessment is a systematic process for quantifying the likelihood of adverse health effects in a population following exposure to a specified hazard. Risk management is the process of selecting and implementing prevention and control measures to achieve an acceptable level of the risk at an acceptable cost. In contrast to risk avoidance, which seeks to counter all possible vulnerabilities, risk management

TABLE 33.5. DISASTER MEDICINE ACTIVITIES RELATED TO CONSEQUENCE MANAGEMENT

Activity	Case management	Incident management
Command and communication	Disaster plan implementation Prehospital medical direction Hospital emergency protocols Redundant communication	Incident command systems HazMat site control Methods of mutual aid
Prevention and control	Personal protective equipment Patient and staff decontamination EMS and ED treatment protocols Mortuary science Occupational health Critical incident stress debriefing Isolation	Warning and risk communication Public service announcements Population protection measures Site decontamination and effluent control Crowd control Mass shelter
WMD effects	Toxicology Traumatology Resuscitology	Infrastructure assessment Environmental health Communications Population health assessment
Terrorism and forensics	Terrorist intelligence Chain-of-evidence preservation Forensic pathology	Terrorist intelligence Crime scene preservation

Abbreviations: ED, emergency department; EMS, Emergency Medical Services; HazMat, hazardous materials; WMD, weapons of mass destruction.

instead weighs the risk of loss against the cost of control measures. As one author stated, "to narrow the scope of the problem, civil defenses against chemical and biologic terrorism should be based on most likely rather than worst case scenarios" (19). While risk avoidance responds to threats based on the worst case scenario, risk management alternatively attaches a systematic prioritization of risk, thereby identifying the most likely events, and then calibrates an associated cost-benefit analysis to guide any resultant prevention and control measures.

Risk management is composed of the following three main elements: risk assessment, cost-benefit analysis, and risk communication. The components of analytical risk assessment related to ICD include asset and loss impact assessment, threat assessment, and vulnerability analysis (Table 33.6). In the case of an ICD, the public health approach is also closely associated with security decision making. Within the context of an event involving a potential adversary, the hazard identification of conventional environmental risk management is instead replaced by the more comprehensive process of threat characterization. This process not only includes an identification of the specific chemical hazards, but also it involves the characterization of potential perpetrators or adversaries in terms of their intent, technical capability, and history.

Each of the key elements of a risk assessment—impact, threat, and vulnerability—is ranked in a graduated system of numerical priority. Risk is quantified according to descriptive and integral parameters and is then calculated as a function of impact, threat, and vulnerability. The formula for risk assessment is as follows:

$$\text{Risk} = (\text{Impact} \times \text{Threat} \times \text{Vulnerability}).$$

Thus, preexisting public health system and infrastructure is recognized as a prerequisite for subsequent countermeasures in the form of prevention and control.

To date, no federal agency has determined and assessed the environmental risk of United States cities based on intelligence assessments, critical infrastructure points, national symbols, future special events, sensitive government or corporate activities, or similar analyses and data to help evaluate cities' key assets and vulnerabilities as related to ICDs.

An April 1998 Government Accounting Office (GAO) report highlighted a model for threat and risk assessment that has diverse applications and does not require a point source, perfect intelligence data, or preattack indicators. In addition, Presidential Decision Directive 62 has also recommended that threat and risk assessments be performed on non-point targets, such as telecommunications, banking, and finance infrastructures (19a).

The remedial action or medical response to an ICD is highly dependent on details that may be discovered in the threat or risk assessment. Geography, population density, infrastructure points, and sensitive government and corporate facilities may also influence impact, threat, and vulnerability. Assessments that include these factors are conducive to preparedness and awareness. Baseline risk assessment also facilitates the postevent application of exposure modeling systems if an intentional release occurs.

The GAO estimates that approximately 2 weeks per city would be required to conduct a risk assessment and determine a prudent and affordable level of response capability.

TABLE 33.6. ELEMENTS OF ANALYTICAL RISK MANAGEMENT

Process	Activities
Impact assessment	Determining critical assets (i.e., a population)
Asset assessment	Identifying undesirable events and expected losses or damages
Loss assessment	Prioritizing assets based on the consequence of loss
Threat characterization	Identifying indications, circumstances, or events with the potential to cause the loss of or damage to an asset
Hazard identification	
Adversary intent	Assessing the intent and motivation of each adversary
Adversary capability	Evaluating the capabilities of each adversary
Adversary history	Determining the frequency of past events
	Estimating the relative threat to each critical asset
Vulnerability analysis	Identifying potential weaknesses that may be exploited by an adversary to gain access to an asset
Potential vulnerabilities	
Existing countermeasures	Recognizing existing countermeasures and their level of effectiveness, which may then be used to reduce vulnerability
	Estimating the degree of vulnerability to each asset and threat
Countermeasure determination	Identifying potential actions that may be taken or physical entities that can be used to eliminate or to lessen one or more vulnerabilities
Prevention	
Control	
Cost-benefit analysis	Identifying costs and benefits of countermeasures
	Conducting cost-benefit and tradeoff analyses
	Prioritizing options
Risk communication	Preparing a range of recommendations for decision makers and/or the public

The report states that "rational, businesslike, collaborative assessment by city, state, and federal representatives can help determine the appropriate minimum requirements for preparedness, given the threats, risks, and vulnerabilities for that city" (20). For this reason, any organized preparedness effort, including stockpiling, education, or planning, should be based as firmly as possible within the scientific methodology of analytical risk management.

Hazard Identification

Conventional environmental heath risk assessment begins with the process of hazard identification, which attempts to determine what release events are likely to occur in a specific region or environment. In the case of unintentional chemical release incidents, the objective is to identify all chemical products within a specific location that may pose a potential health hazard. However, significant difficulties exist in identifying which chemical(s) an adversary or perpetrator may choose to use during an attack.

Literally thousands of hazardous chemicals are currently available to the general public, and more than 600 new chemical substances become commercially available each month (21). Besides the large number of hazardous chemicals that are readily available to the potential enemy, terrorist, or saboteur, numerous other variables may influence the threat agent selection. Some of these variables include the availability of the agent, the ease of production, lethality, its stability in storage, the cost, handling safety for the perpetrator, public risk perception, the ease of delivery or weaponization, and stability in a deliverable state.

Outside of the known military agents, a variety of industrial chemicals may have the potential to cause adverse health effects. The widespread knowledge of these toxicities along with a comparative ease of availability and weaponization may influence terrorists to select industrial chemicals as potential weapon agents. Current hazard assessments are variable depending on the source. The law enforcement and the intelligence communities have reported a growing interest in weapons of mass destruction (WMD) by groups and rogue nations of concern. The GAO states that the intelligence community has "concluded that explosives or other conventional weapons will continue to be the most likely form of terrorist attack over the next decade" (20). The Chemical and Biological Arms Control Institute ranks the intentional releases of industrial chemicals as a relatively higher likelihood when compared to other more exotic agents used in WMD (6).

Despite the enormous challenge presented by the need for identification and prioritization of chemical hazards that may be used by terrorists, certain generalizations may be made to simplify disaster medical preparedness and planning. Toxic chemicals may be categorized by known health effects. Those hyperacute effects then become pertinent relative to guidance during emergency case and incident management. To ease case and incident management, a broad variety of hazardous chemicals may be divided into 13 basic categories (Table 33.7).

Despite the recent publication of operational handbooks and educational programs focusing on antidote therapy, very few antidotes for the treatment of toxic chemical poisoning exist in comparison to the extremely large number of agents that may be used as a WMD. In addition, specific antidotes exist for only a few of the military agents, and a mere handful of therapies are available for all the industrial and commercial chemicals. Table 33.8 contains a partial list

TABLE 33.7. TOXIC CHEMICALS CATEGORIZED BY GENERAL HEALTH EFFECTS

Metals and metallic compounds
Incendiaries
Irritant gases
Asphyxiant gases
Metabolic asphyxiants
Radiologic agents
Teratogens
Corrosives
Explosives
Oxidizers
Pharmaceuticals
Carcinogens
Pesticides

TABLE 33.8. EXAMPLES OF CHEMICAL AGENTS THAT HAVE SPECIFIC ANTIDOTES

Chemical agent	Antidote
Military agents	
Nerve agents	Atropine, pralidoxime
Cyanide	Amyl nitrite, sodium thiosulfate, sodium nitrite, cyanocobalamin
Lewisite	British antilewisite and/or dimercaperol
Industrial and commercial agents	
Heavy metals	Penicillamine
Hydrofluoric acid	Calcium gluconate
Aniline	Methylene blue
Pharmaceutical agents	Naloxone, *N*-acetylcysteine, flumazanil

TABLE 33.9. EMERGENCY MEDICAL CONDITIONS AND NEEDS ASSOCIATED WITH CHEMICAL EXPOSURES

Syndrome and causative agents	Medical therapeutic needs
Burns and trauma—corrosives, vesicants, explosives, oxidants, incendiaries, radiologicals	Intravenous fluid and supplies Pain medications Pulmonary products Splints and bandages
Respiratory failure—corrosives, military agents, explosives, oxidants, incendiaries, asphyxiants, irritants, pharmaceutical agents, metals	Pulmonary products Ventilators and supplies Antidotes, if available Tranquilizing medications
Cardiovascular shock—military agents, pesticides, asphyxiants, pharmaceutical agents	Intravenous fluid and supplies Cardiovascular products Antidotes, if available
Neurologic toxicity—military agents, pesticides, pharmaceutical agents, radiologic agents	Antidotes, if available

of the most broadly available antidote therapies. These antidotes are thought to be stocked in an extremely limited supply in most ambulances and hospitals (22).

Outside of this limited number of antidote therapies, the medical management of nearly all toxic chemical exposures mostly involves supportive therapy. Even if an antidote may be available for a said exposure, many times the clinician may not be able to identify the offending agent in enough time to guide the therapy effectively. If an accurate and rapid clinical diagnosis can be made, treatment may not become available in enough time to be efficacious, especially in cases of involving a nerve agent or the inhalation of cyanide poisoning (23). The demand for medical resources may then be expected to involve mainly critical care and supportive therapeutics.

Thus, the hyperacute health effects of a broad variety of hazardous chemicals, as categorized in Table 33.7, may actually be expected to invoke demands for medical resources that address a quite narrow range of medical conditions. Table 33.9 represents four main basic medical conditions that may be expected to occur as major short-term sequela following severe exposures to any of these chemical hazards. It also identifies eight categories of emergency medical therapeutics that are necessary to treat these four syndrome complexes.

Threat Assessment

ICDs are unique in comparison to other technologic catastrophes, as an ICD is defined by the implication of a willful and malicious intent. In this regard, the disaster management cycle is markedly influenced by the perpetrator of the event. The characteristics of the perpetrator must be taken into consideration as part of the broad range of public health efforts involving prevention, mitigation, preparedness, response, and recovery.

These characteristics of the intentional perpetrator are not a traditional component of most methods for environmental health hazard identification. The process, as it applies to malicious intent, must also incorporate a new component. This component, known as threat assessment, is an integral part of security decision making that is consistent with that performed by the intelligence community. Threat assessment is not limited to the identification of a chemical hazard, but it also extends to the characteristics and behavior of potential adversaries or perpetrators of ICDs. Threat is measured as a function of an adversary's intent, capability to act, and history of actions. Intent may be quantified in terms of understanding the goals and strategies of a potential perpetrator of ICDs. For this reason, disaster planners and managers must have a basic awareness of the methods used to typify a threat assessment as applied to ICDs. These principles may then guide disaster management through the consideration of the particular traits that define these persons as a potential hazard to the public health.

The intent of the adversary may vary according to circumstance. Goals of a state-sponsored war enemy may include any promotion of political, economic, military, ethnic, or religious agendas defined by national leaders. Industrial saboteurs may act with the goal of revenge, self-promotion, or excitement. In addition to those goals of state-sponsored warfare, terrorists may seek to force political change or to gain publicity for a cause. As Thomas Ditzler so aptly stated, "Terrorism may be the only form of assault named for the psychic state it is intended to create." In this sense, understanding the psychologic component of terrorism is important. Terrorists have been known to perform in accordance within the basic principles of psychologic operations. Knowledge of these principles can allow disaster managers to minimize vulnerabilities and to maximize prevention and control measures that are more specific to the risk of terrorism. This may be difficult as marked differences might separate the conceptual framework of the society from that of the terrorist. Contrary to popular thought, terrorists are not 'mad bombers' without method or reason. Instead, they, as a whole, have normal personality distribution and, for the most part, an above-average intelligence. Thus, when compared to the normal population, psychologic pathosis does not appear more prevalent among this group. The intent of these persons to commit mass casualties is no more pathologic than the patriotic intent of a soldier motivated by nationalism, religion, or ethnicity. These groups endeavor to market their views through a highly methodic process of impression management. The final goal is not necessarily that of mass casualties but instead fear. This is best depicted in the ancient Chinese saying, "Kill one; frighten 10,000" (6).

Predicting that chemical attacks resulting in mass destruction are now inevitable may seem easy enough. However, accurate threat assessments may reveal that, while ICDs are possible, they are not necessarily probable (6). While some may view the Aum Shinrikyo subway incident as a watershed event for future attacks, one must remember the negative effect that this event had upon the ongoing functionality and survival of the sect itself. Government retaliation and the revulsion of the Japanese public were strong enough to nullify group leadership and to threaten the entire campaign objective. So, as this example illustrates, many complex factors balance the threat of an ICD, some of which may serve to facilitate the likelihood of an ICD and some that instead lessen its possibility. In recent years, a lack of technical capacity has not been the sole barrier restricting the use of ICDs. This dynamic has also been balanced by other concerns involving factors of self-preservation, morality, politics, and historic precedent (Table 33.10).

Formal threat assessments should include an analysis of these and other factors that may influence the overall risk of an ICD. The Chemical and Biological Arms Control Institute has offered the following set of predictions: (a) future terrorists are more likely to threaten to use chemical and biologic agents than to use them; (b) the use of chemicals will prove more prevalent than use of biologic agents; (c) small-scale attacks are more likely than large-scale attacks; (d) industrial chemicals are more likely to be used than military chemicals; (e) crude dispersal in enclosed areas is the most likely form of attack; (f) future incidents involving chemical and biologic substances may occur, but these are not going to be commonplace (6).

Vulnerability Assessment

Vulnerabilities are any action, circumstance, or event with the potential to cause the loss of or damage to an asset. They are any weakness that can be exploited by an adversary to gain access to an asset. Vulnerabilities to ICDs can result from population demographics, geographic location, behavior, sheltering and building use, operational practices, and occupation. Human vulnerability includes areas involving emotional, psychologic, behavioral, and security issues. In most cases, a set of preexisting countermeasures may already be in place that also serve to prevent and control risk of an ICD among these vulnerable populations. These should be considered in the risk assessment in terms of the procedural, technical, physical, and personnel issues related to ICDs. Tables 33.4 and 33.5 represent the pertinent activities of consequence detection and management, and therefore they provide an example of preexisting countermeasures that should be evaluated and rated in terms of quality, quantity, and efficacy.

Risk Countermeasures

Having objectively quantified the risk of an ICD and then assigned appropriate levels of priority for asset protection, countermeasures can then be undertaken that will reduce or

TABLE 33.10. FACTORS INFLUENCING THE LIKELIHOOD OF INTENTIONAL CHEMICAL DISASTERS

May decrease likelihood	May increase likelihood
Majority of historic precedents tending towards conservatism and a calibrated level of violence	Large-scale and indiscriminate attacks becoming more frequent
Possibility of world revulsion, alienation of constituency, and loss of group cohesion	Racial supremacy, ethnic hatred, and religious fanaticism much less constituency-based
May provoke massive retaliation	High public dread and perception of risk regarding chemical agents
Conventional weapons simpler, less expensive, and more predictable and flexible	Global diffusion of technology, so increased chemical weapon availability
May sacrifice state deniability or anonymity	State-sponsored support with funding, intelligence, and command and technical expertise
Chemical weaponization problematic	Purchase or theft of weapons of mass destruction now more likely
Terrorists perceive themselves as held to a higher moral standard than the targets	Religious terrorists see themselves as answerable only to God
Lack of safe haven states after intentional chemical disaster attack	Emergence of the far right, so increased likelihood of large scale violence
Lack of commensurate demands	More casualties required to maintain public and media interest
Weapons possibly turned against state sponsors, so states are less likely to provide such weapons to subnational groups	

eliminate one or more of the vulnerabilities. Disaster medical and public health countermeasures have been identified in Tables 33.4 and 33.5. Countermeasures include aspects of consequence detection and management, and they effectively function to deter, detect, delay, defend, and defeat the aims of the ICD perpetrator. Although these prevention and control measures must be measured against the potential costs and benefits of such actions, a discussion of ICD consequence detection and management activities are included to exemplify these options regardless of financial constraints.

Consequence Detection Measures

Chance favors the prepared mind.

—Louis Pasteur

To identify and detect the consequences of an ICD, responders must first be aware of characteristics that define these catastrophic events. Medical personnel require training for a differential diagnosis that also includes the adverse health effects of an ICD. An efficient and secure network for the sharing of confidential preincident intelligence must be created so that responders may be forewarned or briefed about ongoing events (16,24). The variety of potential chemical hazards must be identified along with the development of public and professional education programs that incorporate both military and industrial and/or commercial agents without an undo overemphasis on either chemical hazard (24). Civilian public safety, rescue, emergency medical personnel, and medical laboratories need an improved ability to detect and identify a wide variety of toxic substances including, but not limited to, military agents (24). The capacity for community-level ICD event reconstruction that allows for hazard assessment, dispersion prediction, exposure assessment, and laboratory reporting should be enabled (24,25). The capability for integration of information management, passive and active surveillance systems, and epidemiologic investigation should be instituted among national, state, and local health resources (18,19,24).

Since 1990, the Agency for Toxic Substances and Disease Registry (ATSDR) has maintained an active, state-based hazardous substances emergency events surveillance (HSEES) system to describe the public health consequences associated with the release of hazardous substances. Environmental monitoring and the HSEES should reflect an index of suspicion, the threshold, and mechanism for reporting ICD events. Protocols, methods, and case definitions are needed, in addition to scene assessments, for the diagnosis and evaluation of ICD-related casualties (18,19). Guidance for an "all-hazard approach" to incident and emergency management must be available. This should include principles of the planning process, direction and control, communications, warning and risk communication, emergency public information, population protection measures, health and medical issues, mass care, resource allocation, and hazard-specific variations (23,26).

Medical training must include protocols for the isolation and treatment of contaminated patients in addition to operational recovery (27). Limitations and needs for effective personal protective equipment and occupational health training must be identified and maintained (23,24). Research and development efforts must focus on processes for rapid mass triage and the decontamination of large numbers of affected individuals (23,24). Methods for incident management, site control, forensics, mutual aid, and hazardous waste emergency operations involving the broad variety of ICD agents must gain a broad level of consensus and awareness (18,28). Mental health issues are also a very important factor in the health and medical management and detection of a terrorist event (29). National, regional, and local public health departments must be linked in a network of real-time communication with the medical response community, public safety, regional poison control centers, and regional laboratory capacities (18,23). National assets must also be configured to support local responders in a broad variety of activities involving consequence management and detection (18).

SUMMARY

In summary, the prevention, detection, and management of ICD events represent an enormous challenge for the discipline of disaster medicine. While these incidents may have low likelihood, the impact could be catastrophic. Experience in dealing with these rare events is extremely limited. However, the scope of disaster medicine is uniquely characterized to be able to address these complex issues effectively.

A broad range of potential hazards and threats that involve ICDs are possible. However, many striking similarities are found between aspects for the management of an ICD and the many issues related to technologic disasters. Conceptual frameworks that can serve to organize disaster medical activity better are now available to guide future efforts. Methods for ICD consequence detection and management may be successfully addressed using a system of analytical risk management. Experience and knowledge regarding these principles of risk management as applied to an ICD are essential to the development and effectiveness of disaster medicine and public health promotion.

DEDICATION

This chapter is dedicated in memoriam to my lifelong friend Alan Jay Shilling.

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